EVALUATION OF SUBSIDIES PROGRAMS TO SELL GREEN CARS: IMPACT ON PRICES, QUANTITIES AND EFFICIENCY[1]

Juan Luis Jiménez[2] Jordi Perdiguero[3] Carmen García[4]

Abstract

During the recent period of economic crisis, many countries have introduced scrappage schemes to boost the sale and production of vehicles, particularly of vehicles designed to pollute less. In this paper, we analyze the impact of a particular scheme in Spain (Plan2000E) on vehicle prices and sales figures as well as on the reduction of polluting emissions from vehicles on the road. We considered the introduction of this scheme an exogenous policy change and because we could distinguish a control group (non-subsidized vehicles) and a treatment group (subsidized vehicles), before and after the introduction of the Plan, we were able to carry out our analysis as a quasi-natural experiment. Our study reveals that manufacturers increased vehicle prices by the same amount they were granted through the Plan (1,000 €). In terms of sales, econometric estimations revealed an increase of almost 10% as a result of the implementation of the Plan. With regard to environmental efficiency, we compared the costs (inverted quantity of money) and the benefits of the program (reductions in polluting emissions and additional fiscal revenues) and found that the Plan would only be beneficial if it boosted demand by at least 30%.

Keywords: Subsidies; Automobile sector; Difference-in-Difference estimator; Green policies.

JEL Codes: H23; L52; L62; Q58.

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[2] Contact author: Universidad de Las Palmas de Gran Canaria. Facultad de Economía, Empresa y Turismo. Despacho D. 2-12. 35017. Las Palmas de Gran Canaria. Tlf: +34928458191. jljimenez@daea.ulpgc.es

[3] Universitat Autònoma de Barcelona. Departament d'Economia Aplicada. Research Group of "Governs i Mercats" (GiM), and Institut de Recerca en Economia Aplicada (IREA). jordi.perdiguero@uab.cat.

[4] Universidad de Las Palmas de Gran Canaria. carmen.garcia121@alu.ulpgc.es

1. **Introduction**

The automotive industry is widely considered one of the most important manufacturing sectors in a country's economy. Its high level of production and its labor demand make it a visible sector in any economy. The current economic crisis experienced by Western economies starting in 2008 has significantly impacted this industry, particularly in terms of automobile sales.

Reduced sales resulting in increased unemployment in the sector coupled with demands to meet targets for the reduction of greenhouse gas emissions – a result of the United Nations Copenhagen Climate Change Conference and the Kyoto Protocol – has led many Western governments to introduce special programs aimed at increasing vehicle replacement through new purchases.

These programs were essentially designed to fulfill two objectives: increase automobile sales (thereby minimizing redundancies), and reduce greenhouse gas emission levels generated by the vehicles on the road. These policies were implemented in countries such as Germany, Italy, France, the United Kingdom and the United States during 2008 and 2009.

Although there were many countries that introduced these programs and approved their costs in governmental annual budgets, little attention has been paid to their effect on economies and, as far as we know, there are no studies into their effect in Europe. Nor are there any studies into the impact of governmental aid on prices set by industry.[5]

One governmental aid program in the United States that has been extensively analyzed called for the adoption of a hybrid vehicle.[6] The program offered a rebate of up to $2,000 and was introduced in 2001. A new version was introduced in 2005, increasing the rebate to $3,400. Diamond (2009) carried out a first estimate of the impact of this program on the sale of certain hybrid car models (Toyota Prius, Honda Civic and Ford Escape) and the results showed an increase of approximately 18%, depending on the model.

Beresteanu and Li (2011) studied public aid and the effect of gasoline prices on the purchase of hybrid vehicles. The results of the study showed that if the price of gasoline had not increased between 1999 and 2006, there would be 37% fewer hybrid vehicles on the roads. In terms of public aid, the authors estimated that the program stimulated a 20% increase in the demand for hybrid vehicles. Gallagher and Muehlegger (2011) analyzed this same program in United States and found a similar result (a 22% increase in demand).

Other studies include a report by Huang (2010) in which he analyzed the "Cash for Clunkers" program introduced in United States. This program was introduced in March

[5] Sallee (2011) analyzes the effect of subsidies for the purchase of the Toyota Prius hybrid car in its price. Surprisingly, the effect is zero; prices are not affected by the subsidy. The author considers that the effect of current prices on future sales may explain this result.

[6] A hybrid vehicle combines an electric engine and an internal combustion engine.

2009 and offered between $3,500 and $4,500 to exchange an old vehicle for a more energy efficient one. If the savings were between 4 and 9 miles per gallon of gasoline, the owner received $3,500, and if the savings were even greater they received $4,500[7]. The study shows how the average amount awarded ($4,224) boosted demand for more energy efficient vehicles by between 25% and 30%.[8] Other papers like Mian and Sufi (2010) or Li et al (2011) show like the global effect of the program was zero. Both papers find that after the initial increase in sales, they decrease in the months after the program. After few months the accumulative sales return to the normal level and the effect of the program is not really different from zero.

Given that most studies focus on the promotion of hybrid vehicle sales in the U.S market (and not the impact on prices), the objective of this study was to analyze the impact of a program that promotes pollution reducing vehicles (Plan 2000E in Spain) from three different perspectives: firstly, on the prices set by automobile manufacturers (the effect of subsidy on price); secondly, its effect on the sales of automobiles, and thirdly, on the viability of the program in terms of environmental benefits (measured by assessing empirical evidence).

Our study will contribute to the literature surrounding this issue in the following ways: firstly, as far as we know, the impact of public assistance on prices set by manufacturers in the conventional cars has not been previously analyzed. Secondly, studies that analyze European cases are not available in the literature. Thirdly, we provide evidence on the environmental viability of the program, by comparing its costs and the environmental benefits.

The difference-in-difference analyses revealed that the manufacturers' response to the introduction of the Plan was to significantly increase the prices of the subsidized vehicles, thereby keeping a part of the funds. The fact that automobile manufacturers (hereinafter manufacturers) received one part of the credit by increasing vehicle prices illustrates that the effect of the Plan on the sales and on pollution reduction levels is actually quite low, which significantly reduces the efficiency of the Plan. Econometric results showed that the impact of the program on the sales of automobiles was only around 10%, in the best scenario.

Our results also indicate that the costs of the program far exceed the resultant environmental benefits, and as such Plan 2000E not only turned out to be inefficient, but probably was socially undesirable too.

Section 2 describes the characteristics and the implementation of Plan 2000E in detail and Section 3 focuses on the data used in the empirical study, which is presented in Section 4

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[7] An extensive explanation of the "Cash for Clunkers" program is available in Cooper et al (2010) and Yacobucci and Canis (2010).

[8] Alberini et al (1995) present a theoretical model in order to determine user participation in vehicle substitution programs. Nevertheless, the participation ratios estimated from the model are quite distant from those confirmed in empirical studies, reaching 78% by offering only $2,000.

for both objectives (effects and environmental efficiency). Conclusions are given in Section 5.

2. Plan 2000E

The manufacture of automobiles and bicycles in Spain during 2009 was valued at approximately 40 billion euros and employed 145,645 workers that same year. These figures accounted for 11.5% of total production and 7.2% of employment in all manufacturing sectors[9]. These figures demonstrate the importance of this sector in the Spanish economy, and explain why this industry has received so much media attention during the ongoing economic crisis.

To put Spanish automobile manufacturing into an international perspective, Spain was the eighth largest manufacturer in the world and third largest in Europe in 2009. Despite this, there is evidence that starting in the end of 2007, the economic crisis was starting to affect the sector, and by 2009 the sector had reached an alarming level of suffering, with a reduction in year-on-year manufacturing of almost 20% for motor vehicles in businesses with more than two hundred employees, and 35% in the remaining businesses[10].

This negative evolution in the sector in 2008 and 2009 led the Spanish Government to take action (as did other countries with similar problems)[11] by introducing a scrappage scheme that would reactivate sector activity, called Plan 2000E. This Plan would subsidize the replacement of an old vehicle for a new one, with specific characteristics, and was co-financed by the National Government (who contributed 500€), the Autonomous Communities (who contributed 500€) and manufacturers (who contributed 1,000€) with the aim of providing a total subsidy of 2,000€.

Only specific vehicles with the M1 classification could be subsidized (motor vehicles with at least four wheels, designed and manufactured for the transport of passengers) and those with the N1 classification (vehicles designed for the transport of merchandise, whose gross vehicle weight did not exceed 3.5 tons). A list of vehicle requirements is shown in Table 1.

Consumers could benefit from the subsidy by exchanging an M1 or N1 classified vehicle, which was at least 10 years old or with a minimum of 250,000 km on the clock for a new vehicle that did not exceed 30,000€ (prior to applying the subsidy, with VAT taxes included) and met certain emissions criteria. The scheme could also be used for second

[9] MITYC. *Estadística de Fabricación de Vehículos Automóviles y Bicicletas.*

[10] Fundación SEPI (2009). *Las empresas industriales en 2009: Encuesta sobre estrategias empresariales.*

[11] During 2008 and 2009, public assistance was also provided to purchase of vehicles in Germany (2.500€ per vehicle, with a total of 600,000 vehicles being subsidized), Italy (rebate ranged from 1,500€ to 3,000€, depending on the vehicle), France (allocation of 1,000€, with approximately 400,000 vehicles subsidized), the United Kingdom (2,000 GBP, of which the Government contributes 1,000, and the manufacturers the rest) and the United States (rebate of $3,500 or $4,500, according to vehicle fuel consumption).

hand purchases[12] if the car being scrapped was at least 12 years old and the used was less than 5 years old.

The subsidy consisted of a credit of 1,000€ added to the manufacturers price for each vehicle. Once the subsidy was applied (with other applicable discounts) and indirect taxes had been added, the subsidy from the National Government of €500 was applied, in addition to another 500€ from the autonomous community - if they were participating in the scheme [13].

The first stage of Plan 2000E officially began on May 18th 2009 and would end on May 18th 2010, or when the fixed objective was met, which was the financing of 200,000 vehicles[14]. However, the approved budget for Plan 2000E was used up in the first five months, according to data cited from the Ministry of Industry[15] (this is an approximation; the timing is based on the official start date of the program to the end of August[16]). The speed with which the budget was used up caused the government to extend the number of subsidized vehicles by 80,000 in November 2009 (second stage), that is, an additional allocation of 40 million euros[17]. Finally, with the market continuing to report falling annual car registrations and with the government considering that Plan 2000E had had a positive and dynamic effect[18] on the economy, it approved the extension of the Plan once again in 2010. In this last stage (the third stage), the Plan was made effective from January 1st 2010 until September 30th 2010, or until the Plan had met its stated quantitative objectives i.e. subsidizing 200,000 vehicles. Plan 2000E officially ended in July 2010. In the first four months of 2010 75% of the allocated vehicles had been accounted for and it was expected that the full budget would be used up by May or June[19].

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[12] The specific conditions of the Plan applied to second hand purchases are very restrictive. In consequence, the amounts of sales of this type of cars represent a low percentage of total sales in the market. Moreover, it is quite difficult to obtain the prices and sales of second hand purchases vehicles. This is why we will not consider the impact of the Plan 2000E in those vehicles.

[13] As will be mentioned, not every Autonomous community did participate in the Plan. In fact, Madrid and La Rioja did not take advantage of the Plan from the beginning, and later on other communities also stopped offering assistance.

[14] See footnote 9.

[15] *"El Plan 2000E ha agotado ya el 75% de sus fondos". Expansión* (14/04/2010).

[16] *"Cien millones en ayudas para el Plan 2000E".* http://motor.terra.es/ultimas-noticias-actualidad/articulo/cien-plan-2000e-52271.htm

[17] BOE (Núm. 260, de 7 de noviembre de 2009. Págs.: 92952-02053). Real Decreto 1667/2009, de 6 de noviembre, por el que se modifica el Real Decreto 898/2009, de 22 de mayo, por el que se regula la concesión directa de subvenciones para la adquisición de vehículos, Plan 2000 E de apoyo a la renovación del parque de vehículos, y se amplía el número máximo de vehículos a financiar en 80.000 vehículos adicionales.

[18] BOE (Núm. 7, de 8 de enero de 2010. Págs.: 2015-2020). Real Decreto 2031/2009, de 30 de diciembre, por el que se regula la concesión directa de subvenciones para la adquisición de vehículos, "Plan 2000E" de apoyo a la renovación del parque de vehículos durante el año 2010.

[19] *"El Plan 2000E ha agotado ya el 75% de sus fondos"; Expansión* (14/04/2010). "El Plan 2000E cumple su primer año de vigencia a punto de agotar sus fondos"; *Cinco Días* (17/05/2010).

Table 1. Requirements and planning

Characteristics	Price	Emissions	Others
Subsidized vehicle	< 30,000 €	<120 gr./Km (ecological)	M1
		<149 gr./Km (innovative)	M1: Stability control; presence detection
		<149 gr./Km	M1: Three way-catalyst; EGR valve
		<160 gr./Km	N1
Planning			
Stage	**Legal period**	**Real period**	**Number of vehicles**
First	May09-May10	May09-Aug09	200,000
Second	Nov09-Dec09	Nov09-Dec09	80,000
Third	Jan10-Sep10	Jan10-Jun10	200,000

Source: Own elaboration.

Almost all of the Autonomous Communities (hereinafter Communities) that participated in Plan 2000E (including Ceuta and Melilla) had signed up to the Plan by 2009, with Madrid and La Rioja being the two exceptions. Nevertheless, they both offered discounts on registration tax, with Madrid offering 20% and La Rioja between 15% and 38%. Some Communities such as Navarra, Galicia, Valencia and Cataluña offered their own plans, some of which increased the requirements set out by the Government. The rest of the Communities opted to contribute the standard 500€ set by the Government.

In 2010 (during the third stage of the Plan) certain Communities such as Canarias, Asturias, and Islas Baleares were excluded because the funds had been used up. Other Communities such as País Vasco passed legislation in favor of the new Plan, but used up the funds quickly (by March 2010), while Galicia decided not to implement Plan 2000E (although it did subsidize efficient vehicles).

In the first stage, there was a degree of uncertainty amongst the Communities as to how to react to the Plan; these doubts had increased by the third stage in 2010. Given that it was impossible to obtain detailed information on sales in each of the Communities, we measured the average impact of the Plan, i.e. variations in regional responses to the Plan.

The characteristics of the Plan previously indicated allowed us to address this study as a quasi-natural experiment. As pointed out by Lafontaine and Slade (2008), a natural experiment must meet three criteria: 1) that there is an exogenous change in the market; 2) that there is a group affected by the change; 3) that there is a group that is not affected by the change, which fulfills the control group function.

The introduction of the Plan meets these criteria: 1) the introduction of the Plan is a political decision, an agent that does not operate in the market and therefore the change is

not produced as a consequence of actions by the active manufacturers in the market. Although the introduction of the plan can respond to the economic crisis, automobile operators could not anticipate the criteria to be subsidized, or the exact moment that it would implemented; 2) the introduction of the Plan allows us to have a group of different versions of vehicles affected by the Plan (those that satisfy the criteria to join the Plan); 3) Plan 2000E creates a set of equal versions (even those found within the same vehicle model) that cannot be included in the Plan and hence represent an excellent control group. As the introduction of Plan 2000E meets the criteria of a natural experiment, which allows us to apply a difference-in-difference estimator, we can estimate the effect of the program on the prices set by the manufacturers in a relatively simple way. Since the two groups were formed after the introduction of the Plan they are not considered random – they were created by the Plan – we had to control our estimations by using characteristics that determine whether a vehicle belongs to one group or another i.e. the pollution level, which was estimated based on the horsepower of the vehicle.

Although there are some positive reviews of the Plan, such as that from The Ministry of Industry, Tourism and Commerce who reported that the Plan generated good results and the Federation of Automobile Dealers Associations (*Federación de Asociaciones de Concesionarios de Automoción*) who were satisfied with the extension of Plan 2000E and the increase in sales reported in some months, there are still criticisms about the uncertainty of the Plan and the delays in the payments received[20].

The Spanish Competition Authority (*Comisión Nacional de la Competencia, CNC*) has stated their concerns about the effects of the Plan on vehicle prices and that they have reason to believe that the automobile dealers had incentives to increase prices, not only to counteract the discount but to absorb part of the subsidy received by the consumers. According to the CNC (2009), it was expected that one result from Plan 2000E would be increased sales, reduced prices paid by the consumer and increases in the price received by the dealer, in a way that the difference between the price paid by the purchaser with the subsidy and the price that would be paid without the subsidy would be less than the subsidy itself.[21]

3. Data

To achieve our objective, we used a customized database with different sources, which included factory price, vehicle sale price to the public[22], vehicle characteristics (security and comfort variables), monthly sales of each brand, as well as annual sales per vehicle model,

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[20] Press release- FACONAUTO: *"La incertidumbre en las CC.AA respecto al Plan 2000E ralentiza la venta de coches en enero"* (15/01/2010); *"La incertidumbre en los concesionarios sobre el Plan 2000E frena las ventas en abril"* (16/04/2010); *"Las Administraciones públicas adeudan a los concesionarios de automoción 13,9 millones"* (23/06/2010).

[21] Spanish Competition Authority (Comisión Nacional de la Competencia, 2009). *II Informe anual sobre ayudas públicas. (*2nd annual report on public assistance*).*

[22] The difference between the sale price to the public and the factory price are the registration taxes, indirect taxes and transport.

and some control variables on income evolution (national Gross Domestic Product) and complementary goods prices (international crude price).[23]

The database contained prices (when the price for specific versions of a vehicle is always modified) for the period between January 2007 and September 2010 and included vehicles from 35 brands sold in Spain. These prices change usually two or three times a year. This equated to 732 specific versions,[24] which had to be available on the market before and after the implementation of the Plan (which is one of the advantages of the average analysis carried out by the CNC, which is done by model). Table 2 shows the main descriptive statistics used in the database, distinguishing between subsidized and non-subsidized vehicle.

Table 2. Descriptive statistics by type of vehicle

Variables	Mean		Standard deviation		Minimum		Maximum	
	S	Non-S	S	Non-S	S	Non-S	S	Non-S
Manufacturer Price	15557.8	23487.4	4909.5	6547.9	7414.3	6995.9	24345.7	37801.6
Gasoline	0.38	0.51	0.49	0.50	0	0	1	1
Horsepower	99.9	155.4	27.0	38.0	55	60	177	265
Guarantee (months)	28.3	31.3	9.8	12.3	24	24	84	84
Trunk capacity	1007.7	1322.4	439.9	597.1	267	267	2800	3423
ABS	1	0.99	0	0.08	0	0	1	1
Number of airbags	4.3	5.44	1.9	1.6	1	0	8	8
Power assisted steering	0.95	0.94	0.22	0.24	0	0	1	1
Monthly sales per brand	3370.6	2836.1	2603.1	2980.1	160	3	12922	16771
Annual sales per model	8424.4	2781.8	11459.5	7848	18	1	55132	77847
GDP	266691.8		10073.61		251910		280679	
Crude	71.58		25.13		39.95		132.72	
Subsidized	0.39		0.49		0		1	

Source: Own elaboration.

[23] Price data and characteristics were obtained from the website of Asociación Nacional de Vendedores de Vehículos a Motor, Reparación y Recambios (GANVAM). Market data on monthly vehicle registrations were obtained from the Asociación Nacional de Importadores de Automóviles, Camiones, Autobuses y Motocicletas (ANIACAM). Nominal GDP came from INE and international crude prices from OPEC.

[24] A breakdown of the versions in our database follows; 289 are subsidized vehicles, and 443 versions are non-subsidized.

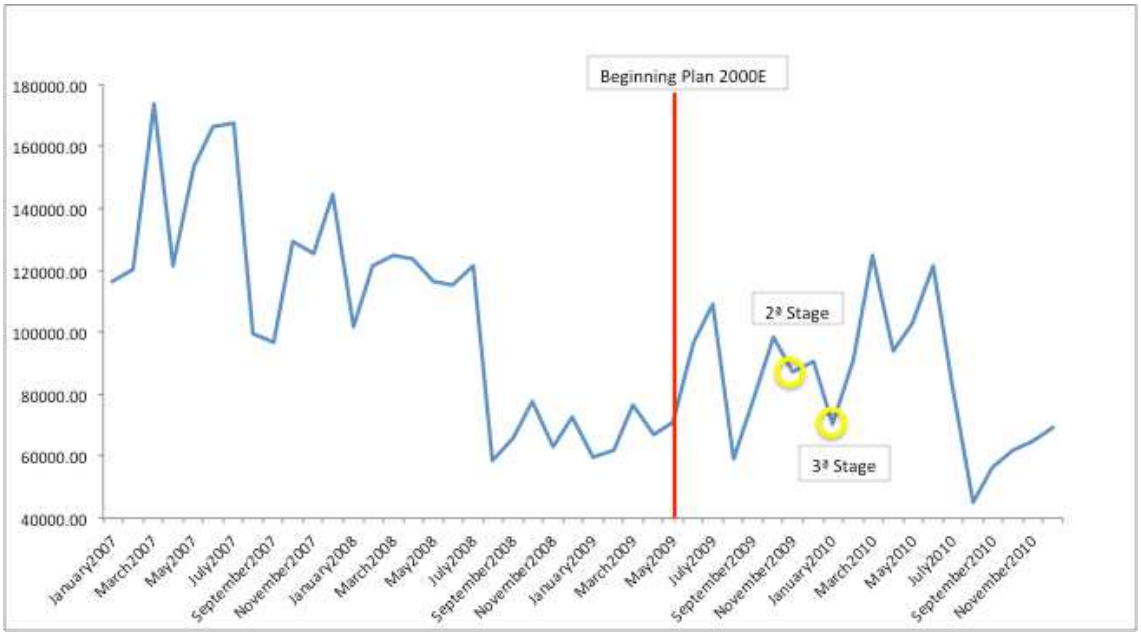
Note: *S* is Subsidized vehicle. *Non-S* is non-subsidized vehicle.

The database includes those vehicles that have a public sale price of less than 50,000€ for two reasons: firstly, Plan 2000E establishes a requirement that the car price be less than 30,000€; secondly, and most relevant, because the competition is diverse between vehicles with very high prices than those with low prices. It is expected that the vehicles that cost more than €50,000 would belong to a distinct product type market and would not directly compete with the identified automobiles in the Plan.

Table 2 shows the average price of vehicles per brand, differentiating between subsidized and non-subsidized vehicles. The prices ranged from approximately 7,000€ to 38,000€. 38% of subsidized cars (51% of non-subsidized) used a gasoline engine with 100 horsepower (155) and an average guarantee of 28 months (31 for non-subsidized). The majority of the vehicles had anti-lock braking system (ABS) and power steering. During the study period, the average monthly sales per brand represented 3,699 vehicles, and the price of crude ranged from $39.95 to $132.72 per barrel.

Figure 1 shows monthly trends in vehicle sales; the point when Plan 2000E began is highlighted in red. From this date on and after each extension of the Plan, an increase in vehicle sales was observed. Nevertheless, vehicle sales clearly vary depending on the month being observation. After the introduction of Plan 2000E, the only months in which a different pattern was observed comparing the same months in different years were July 2010 (a fall in car sales was observed and the date coincides with the end of the Plan), and November 2010 (an increase in sales was observed, even though Plan 2000E was no longer in place). With regard to the remaining periods when Plan 2000E was in place, the average monthly vehicle sales followed the same trends seen in previous years.

Graph 1. Monthly Automobile Sales in Spain



Source: ANIACAM. Own elaboration.

Given the uncertainty during the application of Plan2000E, we wanted to identify whether there were any variations in behavior at the different stages of the Plan so we considered the different stages separately and assessed behavior. The first stage under consideration was the first four months after the Plan was officially launched (see footnotes 13 and 14), which ran from May to August 2009. This period saw the maximum availability of funds and maximum interest from the Communities. For the second stage, we considered the remaining period for the Plan, which ran from September 2009 to June 2010; this period definitively marked the end of the budget. These months are considered as a single group because of the uncertainty when, during September and October, it was discovered that funds were limited. In addition, there was continued uncertainty when the budget was increased at the end of 2009 and again in 2010.

In the other estimates we considered three periods: May to August 2009, September to October 2009 (when funds were limited and in some cases extremely scarce, even though these months continued to form part of the initial stage of the Plan), and November 2009 to June 2010 (because in November 2009 and January 2010 new budgets were established, thus there were additional funds made available during these months to allow Plan 2000E to continue).

In the proposed analysis by the CNC, it is stated that there is reason to believe that behavior varies depending on which price model is in place; subsidized or non-subsidized. Table 3 shows a similar analysis into the average prices for subsidized and non-subsidized vehicles before and after the introduction of the Plan. The analysis was carried out for the two periods highlighted above.

Table 3. Average prices (nominal euros) by vehicle and period

	Before	**After (1)**		**After (2)**		
		May-Aug09	Sep09-Jun10	May-Aug09	Sep-Oct09	Nov09-Jun10
Subsidized vehicles	15,766.90	15,804.2	14,267.5	15,804.2	15,068.8	13,754.1
Non-subsidized vehicles	24,065.50	22,203.3	20,033.2	22,203.3	18,988.9	21,911.6

Source: Own elaboration.

We observed that trends in average prices of the subsidized vehicles and non-subsidized vehicles varied. In the first stage, while the prices for non-subsidized vehicles fell 7.7%,

there was a slight increase (0.2%)[25] in average prices for subsidized vehicles. In following stages, all of the models saw a drop in prices as a result of the situation in the previous stage and this was more prominent in the non-subsidized vehicles: between September 2009 and June 2010, average prices for vehicles in the subsidized group fell 9.5%, while those in the non-subsidized group fell a further 16.7%.

Although these results may reflect an impact of the subsidy that contrasts with what the Government expected, they must be analyzed with caution; being descriptive, they do not account for supply factors (those which affect brand prices) or demand factors (perhaps there is a different behavior in the sales between subsidized and non-subsidized vehicles after the introduction of the Plan) so we had to be careful not to report inaccurate conclusions.

An econometric analysis of the prices was carried out to determine whether there was a variation in price trends associated with vehicle type.

4. Empirical strategy

The present study has two objectives. The first is to analyze the effect that Plan 2000E had on the manufacturing prices of vehicles included in the Plan.[26] We created an equation in which vehicle prices are a function of vehicle characteristics, total sales by brand (ideally we would use exact sales by automobile version, however this data is not publically available), the economic evolution of the country, the official price of crude oil and possible timing effects. These details are addressed in Section 4.1.

Usually the difference-in-difference estimators are implemented to analyze the effects of this type of programs. However, we do also implement the matching estimators, in order to solve some of the problems produced by that methodology. Results are shown in section 4.2.

Once we observed the impact of the program on prices set by the manufacturers, we then set out to determine whether the Plan was viable by estimating the benefits (i.e. the reduction in greenhouse gas emissions and the tax revenue derived from increased sales), and the costs derived from its implementation (i.e. the volume of public resources invested in the Plan).

4.1. Effect of Plan 2000E on prices

The forecast carried out considered the exact versions of vehicles that were available before and after the introduction of Plan 2000E, which only applied to vehicles with a sale price not in excess of 50,000€. Similarly, given the differences in vehicles within categories, we

[25] We carried out a test on average differences for each type of vehicle and compared the before with the first stage. In the case of subsidized vehicles the average difference hypothesis is accepted (increase in first stage), while non-subsidized are rejected.

[26] Given the high level of correlation, note that the forecasts do not vary considerably if the analysis is carried out with public sale price.

included an option that allowed us to carry out a cluster analysis by price and horsepower and thus obtain stronger results[27]. This allowed us to control potential differences in errors according to price bracket.

The estimate by Berry et al. (1995) is the most commonly used for demand estimates and states that vehicle price and characteristics determine their sales. In this study, the characteristics of Plan 2000E meet the criteria of a quasi-natural experiment, meaning we can estimate the effect of the Plan using a difference-in-difference estimator. This allows us to have a control group (the versions of vehicles that are non-subsidized) and a treatment group (the versions of vehicles that are subsidized and meet the criteria for Plan 2000E). The correct implementation of difference-in-difference estimator requires that the differences between both groups (control and treatment group) are minimal, excepting from the treatment. The availability of versions of vehicles that are non-subsidized and versions that are subsidized in our database allows the implementation of difference-in-difference, being the adherence to the Plan the only contrast between them. If there are differences between groups, the variable responsible for the differences must be controlled. In this study, the only difference between the control group and the treatment group is the pollution level, which must be controlled so that our estimations are not biased. Vehicle horsepower can be used to estimate the pollution level and thus allows us to measure and control this difference between the two groups. It is important to note that there are no other differences between the two groups with respect to the remaining characteristics because the same versions of cars were used in each group. This type of methodology is frequently used to analyze the effect of public policies. One example is a study by Albalate (2008) who assesses the impact of programs to reduce alcohol levels in European motorists.

The first part of the methodology is to estimate the following equation:

$$\begin{aligned} Manufacturerprice_{it} &= \beta_0 + \beta_1 \text{Subsidized}_i + \beta_2 \text{Firststage}_{it} + \\ &\beta_3 \text{DIDFirststage}_{it} + \beta_4 \text{Secondstage}_{it} + \beta_5 \text{DIDSecondstage}_{it} + \\ &\beta_6 \text{Monthlysales}_{it} + \beta_7 \text{Gasoline}_i + \beta_8 \text{Horsepower}_{ii} + \beta_9 \text{Guarantee}_i + \\ &\beta_{10} \text{Trunkcapacity}_i + \beta_{11} \text{ABS}_i + \beta_{12} \text{Numberofairbags}_i + \\ &\beta_{13} Powerassistedsteering_i + \varepsilon_{it} \end{aligned} \quad [1]$$

$Manufacturerprice_{it}$ is the wholesale price for each version of vehicle i at moment t. We used the following exogenous variables to try to explain what affects it:

1. $Subsidized_i$: binary variable that takes value 1 if the version is a subsidized one, i.e., if the vehicle is included in the Plan.
2. $Firststage_{it}$: binary variable that takes value 1 if wholesale price belongs to any of the four months of the first stage: May, June, July and August 2009. General effects on

[27] The cluster analysis used *K-means* methodology to create groups. Calinski-Harabasz pseudo F-statitisc has been implemented to determine the optimal number of groups, seven in this case. See Calinski and Harabasz (1974).

prices in this stage are captured by this variable, without differentiating between subsidized and non-subsidized vehicles.

3. *DIDFirststage$_{it}$:* this takes value 1 for subsidized vehicles in the first four months of first stage. It is the product by two latter binary variables (1 and 2). It is the difference-in-difference estimator for the first stage of the Plan. A positive estimation of this variable indicates that prices of subsidized vehicles have increased compared to non-subsidized vehicles.
4. *Secondstage$_{it}$:* binary value that takes value 1 for the rest of the months in which the Plan is valid. It spans September 2009 to July 2010. This variable includes some of the first stage (two months in which the funding was over: September and October 2009), the second and third stage of the Plan together.
5. *DIDSecondstage$_{it}$:* It is the difference-in-difference estimator for the latter variable (second stage). Its interpretation is the same as variable number 3.
6. *Monthlysales$_{it}$:* this variable covers monthly sales (in units) of each brand during the period in question. Some endogeneity problems arise because these sales are influenced by the price set by manufacturer. For this reason we use a two-step estimator (Two Stage Least Minimum Squares) where the instruments are the Spanish GDP from 2007 to 2010 (measured on an annual basis in millions of current euros), two temporal variables (year and summer[28]) and crude oil (Brent crude oil price, measured in dollars per barrel).
7. *Gasoline$_i$:* binary variable that takes value 1 if the vehicle uses gasoline. It takes value 0 if the vehicle uses diesel.
8. *Horsepower$_i$:* the horsepower of the vehicle.
9. *Guarantee$_i$:* the length of guarantee offered by the wholesaler (expressed in months).
10. *Trunkcapacity$_i$:* it measures the capacity of the trunk and is expressed in liters.
11. *ABS$_i$:* binary variable that takes value 1 if the vehicle has the ABS braking system.
12. *Numberofairbags$_i$:* it is the number of airbags included in the car.
13. *Powerassistedsteering$_i$:* binary variable that takes value 1 if the car has power assisted steering.

We also estimate the following equation:

$$\begin{aligned}\text{Manufacturerprice}_{it} &= \beta_0 + \beta_1\text{Subsidized}_i + \beta_2\text{Firststage}_{it} + \\ &\beta_3\text{DIDFirststage}_{it} + \beta_4\text{Septoct}_{it} + \beta_5\text{DIDseptoct}_{it} + \beta_6\text{Nov09june10}_{it} + \\ &\beta_7\text{DIDNov09june10}_{it} + \beta_8 \textit{Monthlysales}_{it} + \beta_9\text{Gasoline}_i + \\ &\beta_{10} \textit{Horsepower}_{ii} + \beta_{11}\text{Guarantee}_i + \beta_{12}\text{Trunkcapacity}_i + \beta_{13}\text{ABS}_i + \\ &\beta_{14}\text{Numberofairbags}_i + \beta_{15}\text{Powerassisteddirection}_i + \varepsilon_{it}\end{aligned} \quad [2]$$

The new variables considered are:

1. *Septoct$_{it}$:* binary variable that takes value 1 if price is for the period between September and October 2009.

[28] It is a binary variable that takes value 1 for July and August. It is included due to seasonality of sales in summer period.

2. $DIDseptoct_{it}$: difference-in-difference estimator for September and October 2009.
3. $Nov09june10_{it}$: this variable takes value 1 for this range of months. It comprises the second and third stages of the Plan.
4. $Didnov09june10_{it}$: difference-in-difference estimator for months included in the second and third stages.

The results from the forecasts in Equations [1] and [2] are shown in Table 4. In both cases the dependent variable is the manufacturer price from version *i* in period *t*.[29]

[29] As suggested Albalate (2008) we estimated the same model incorporating dummy variables for years prior to the Plan, differentiated for the car's versions affected and unaffected by the Plan. The econometric result indicates that both groups follow the same trend before the Plan, so the result of the difference-in-difference estimator would reflect the specific effect of the Plan and not the previous evolution of both groups. The Chi2 is equal to 1.58 and we can not reject null hypothesis that the trend of affected and unaffected versions follow the same trend at 45.49%.

Table 4. Price equations estimations[30]

Explanatory variables	Equation 1	Equation 2
Subsidized	-1894.25(1269.83)	-1917.48 (1243.63)
First Stage	352.59 (382.24)	352.46 (389.41)
DID First Stage	**938.36* (522.79)**	**1012.67** (530.33)**
Second Stage	1032.42 (583.81)	
DID Second Stage	**-1112.71 (1140.61)**	
Sept-Oct		874.42 (1047.08)
DID Sept-Oct		**-2268.85 (1556.67)**
Nov09-June10		1435.84 (933.35)
DIDNov09-June10		**-422.10 (1515.64)**
Monthly Sales	-0.49*** (0.18)	-0.54*** (0.16)
Gasoline	-3532.98*** (613.03)	-3460.9*** (653.59)
Horsepower	112.28*** (9.62)	111.04*** (8.54)
Guarantee	-99.50*** (20.54)	-103.09*** (18.74)
Trunk capacity	0.20 (0.31)	0.27 (0.34)
ABS	618.09 (3046.6)	725.28 (3149.01)
Number of airbags	217.22 (173.75)	232.19 (185.19)
Power assisted direction	829.46 (1068.32)	842.52 (1106.32)
Constant	9330.71*** (3479.00)	9432.54*** (3458.07)
Observations	904	904
R^2 (centered)	0.78	0.78
F-test	1.1e+08***	1.1e+09***

[30] We have estimated these equations including fixed-effects by model. All results remain but there are two main changes: firstly, the difference-in-difference estimator in first stage is significant and it reaches 480 €; secondly, the coefficient of guarantee turns into positive.

Note 1: *** 1%, ** 5%, *10% significance test. Robust standard errors shown in brackets.
Note 2: Monthly sales by brand have been estimated using the following instruments: GDP nominal, year, summer and crude price.

The explanatory capacity of the model was approximately 78% and the F-tests were accepted at 1% in all of the cases.

With respect to the explanatory variables, the quantity of vehicles sold is significantly low, which explains the inverse relationship between price and quantity. Recall that this variable is instrumented based on GDP, price of crude, year and summer[31]. Some characteristics of the vehicles are significant and determine that diesel vehicles, with greater horsepower or larger trunks, are factors that increase the vehicle manufacturer price. It is interesting to observe that the vehicles with longer guarantees have lower prices. A test was carried out on some brands that are found in lower market segments, and revealed how they offered a longer guarantee in this period[32].

Nevertheless, the variables of greatest interest in the study are difference-in-difference estimators. Both forecasts gave the same result: during the application of the first stage of the Plan, subsidized vehicle prices increased by approximately 1,000 euros compared to non-subsidized vehicles. So we can conclude that during this period (from May to August 2009), a positive effect was observed on the prices of subsidized vehicles. Diamond (2009) indicated that manufacturers could incorporate public assistance funds in their price structure and thus establish a higher price for vehicles. Incorporating this concept into our study, we can say that a large part of the subsidy could go directly towards subsidizing the manufacturers without significantly influencing the adoption of new vehicles, which would work against the program objectives. However, the report by the CNC (2009) indicated that Plan 2000E would probably result in an increase in the nominal and effective price received by the dealer by about 1,000 euros, since they have incentives in maintaining the same price prior to the introduction of the Plan.

One aspect that we want to discuss is the possibility that consumers buy subsidize cars rather than non-subsidized vehicles. In this case our control group would be affected by the Plan and the difference-in-difference estimator would be biased upward. In this case, the coefficient of the D-i-D estimator does not reflect an increase in the prices of subsidized vehicles but the increase in the price difference between subsidized and non-subsidized vehicles. This increase in the price difference would be partly explained by the increase in prices of subsidized vehicles (ownership of part of the grant by firms) and the effect of sales on prices. In any case the difference-in-difference estimator would measure in an efficient way the relative price difference between subsidized and non-subsidized cars caused by implementation of the Plan.

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[31] The Kleibergen-Paap and Stock-Yogo statistics indicate that our instruments do not properly solve the problem of endogeneity of the monthly sales by brand variable. This fact can make the coefficient of this variable be biased towards zero, so the effect of sales on price could be greater.

[32] In fact, the longest guarantee is given by KIA (84 months). Nissan offers 36 months, Seat, 24.

We have not found any other analysis in the literature that focus on the impact of public assistance in established manufacturer prices of conventional vehicles[33]. Nevertheless, Busse et al. (2006) showed how consumers obtained between 70% and 90% of the discounts offered directly to consumers, while the discounts offered to the vehicle dealers only reached 30% or 40% of consumers. The authors believe that the information asymmetries are responsible for these differences.

Therefore we can conclude that in the first stage of the Plan by increasing their prices by 1,000 euros for the subsidized versions of certain vehicles, the manufacturers "collected" this amount rather than it being passed on to the consumer,. At this point it is not possible to determine the effect of different prices on different types of vehicles, likely due to the uncertainty created by the Plan. In summary, half of the fixed 2,000€ subsidy in the Plan was taken by the manufacturers and thus in reality the Plan consisted of a 1,000€ subsidy paid to the consumer upon replacement of an old vehicle, and the same amount paid to the manufacturers. The part of the Plan that ended up being the subsidy to the manufacturers obviously does not create or reduce pollution levels nor does it increase vehicle sales; thus the efficiency and effectiveness of the Plan are unclear.

4.2. Average effect of Plan 2000E

Academic literature has been referred to as unconfoundedness, exogeneity, ignorability or selection on observables when regression models have been used. However comparisons made between treated and the control groups remove any self-selection bias. Adjusting treatments and control groups for differences in covariates, or pretreatment variables, is the key to obtain causal inference of effects.

Matching analysis was first proposed by Rubin (1974), although Rosenbaum and Rubin (1983) is the seminal paper in this field. Let Y_1 represent the outcome (here, manufacturer price) in the case of a unit (a version of a car) exposed to treatment (subsidized version by *Plan2000E*, described in Table 1). By analogy, Y_0 is the outcome if the unit is not exposed to treatment (D=0).

Our interest is defined by the difference between Y_1 and Y_0, so it yields a problem of inference with missing data. In our specific case, we are interested in estimating the average effect on prices of subsidizable vehicles of the Plan 2000E, which can be defined as:

$$E\left(Y_1 - Y_0 \middle| D = 1\right)$$

A set of observable characteristics (Z) affects both treatment status and potential outcomes. Using the untestable conditional independence assumption and a requirement for identification, the Average Treatment effect on the Treated (hereafter, ATT) can be identified as:

[33] Sallee (2011) focus in the effect on the Toyota Prius hybrid car.

$$ATT = E\left(Y_1 - Y_0 | D = 1\right) = E\left(E\left(Y_1 - Y_0 | D = 1, Z\right)\right) =$$
$$= E\left(E\left(Y_1 | D = 1, Z\right) - E\left(Y_0 | D = 0, Z\right) | D = 1\right)$$

As considered in Heckman et al (1997), a difference-in-difference analysis may include two sources of bias: the first one arises when the program affects certain versions, but there are no comparable versions to which the program cannot be applied and vice versa. The second bias arises from different distributions of the vector of observable variables that affect our endogenous variable within the two groups of vehicles.

The use of matching estimator eliminates these two potential biases by pairing treatment versions of vehicles (subsidized vehicles) with control groups (non-subsidized vehicles) that have similar observed attributes.[34] This is one of the main advantages of matching analysis respect to former empirical approach. The main hypothesis is whether it exists any unobserved variable we have not included in instrumental variable regression (hereafter, iv-regression). Differences in matching and iv-regression are the key issue.

In our case, we have calculated the average treatment effect on the treated by propensity-score matching estimator. This ATT has been obtained by using the Nearest Neighbour Matching method.[35]

Table 5 summarizes matching estimator outcome. In all estimations we have included as exogenous variables the following: "DID first stage", "monthly sales", "horsepower", "guarantee", "trunk capacity", "abs", "number of airbags" and "power assisted direction", described all of them in table 2. The estimation has been done using bootstrap option.

Table 5. Summary of results of Matching estimator

	Manufacturer price
Public Sale Price <30,000	1,514.18*
Public Sale Price<50,000	1,085.15*

Note: *** 1%, ** 5%, *10% significance test.

[34] See Galiani et al (2005) for an interesting application of this method.

[35] Four of the most widely matching methods are the Nearest Neighbor, Radius, Stratification and Kernel. None of them is *a priori* superior to the others. See Becker and Ichino (2002) for a further explanation.

If we consider vehicles with price lower than 50,000€, the same assumption we did in equations 1 and 2, results show an average effect of prices of 1,085€. This means that the price of subsidized vehicles increased by approximately 1,000€ respect to non-subsidized ones. Similar to the previous discussion, the ATT does reflect the increase in the price difference between both types of vehicles in the same way the D-i-D estimator does. It is the same result that we obtained previously, what leads us to assume the robustness of the diff-in-diff estimators.

However, if we only analyse the impact on prices of vehicles cheaper than 30,000€, restriction imposed by the Plan, we can see an increase on prices of 1,500€. This result shows how the effect is higher when considering only vehicles that could have been subsidized in terms on prices.

4.3. Environmental efficiency of Plan 2000E

To estimate the benefits of the program[36], we calculated the benefits of reduced greenhouse gas emissions generated by the vehicles included in the Plan and the tax revenue generated from increased sales.

To quantify the benefits of reduced greenhouse gas emissions we assumed that the Plan replaced cars with average greenhouse gas emission levels of 1990 indicated by the European Union (180 grams de CO_2/Km) with less polluting cars i.e. those included in the subsidized range of vehicles described in Plan 2000E (133.92 grams of CO_2/Km) (see Table 7).

After calculating the reduction in pollution production per kilometer, we multiplied these savings by the number of kilometers that the car would travel after one year (24,000 km), by the number of years this car could expect to run (15 years)[37] and by the number of cars included in the Plan (461,838 vehicles). This allowed us to determine the number of tons of CO_2 emissions that would be avoided as a result of the Plan, which we could then translate into a monetary value. This was achieved by multiplying the number of tons of CO_2 by the average price of emission rights of a ton of CO_2 in the market during 2010 (€14.32).[38]

The other element of Plan 2000E that brought benefits was the increase in tax collected from the sale of automobiles. The sale of any type of vehicle generates revenue for the public treasury from Value Added Tax (VAT) and vehicle registration tax (IM). In this case, since a 2,000 euro subsidy was available for the purchase of a vehicle, the Treasury

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[36] It is not our objective to perform a Cost-Benefit analysis, since we do not have information on the reduction in claims due to new vehicles or the time reduction displacement that could occur due to the improvement in their technical characteristics, elements that would improve the benefits from the Program. In addition we assume a fixed price for emitted CO_2 and that all variables increase at the same interest rate.

[37] Following the European Commission et al (1999), the average lifetime of a vehicle is between 9 and 10 years, with exceptions that can reach 15.

[38] There are other emissions benefits of retiring older vehicles, as the NOx emissions reductions. However there are nor market nor emissions rights for this and it cannot be included.

Department would receive additional revenue, since the subsidy would be included as an income increase and thus be declared in individual income tax filings (IRPF).

This income is very important, as seen in the report by the Union of Analysts of the Spanish Treasury Department (GESTHA). In this report they estimated that each one of the vehicles generated 2,643€ in revenue with the following breakdown: 196€ from income tax, 1,958€ from VAT and 489€ from vehicle registration tax. These figures were actually used by the analysts at the Spanish Treasury Department to ensure that Plan 2000E was profitable. The result was estimated revenue of approximately 1.2€ billion, which was greater than the costs of the Plan.

It is important to highlight that these results are only accurate if we assume that all users that took part in the Plan would not have changed their vehicle had the Plan not been in place. This assumption is reflected in the first column of Table 7, in which we assume that the 461,838 vehicles included in the Plan account for newly created demand.

Nevertheless this data is not reality, so to estimate the effect of the Plan on subsidized vehicle sales we followed Equation 3. In these forecasts, unlike those shown in Table 4, we used annual sales by model. We did this because sales by brand have an associated monthly periodicity, which tells us with greater variability that we are observing a monthly effect of the Plan. However, to distinguish between subsidized and non-subsidized models we carried out a sales forecast with annual figures by model.

We created the following equation:

$$\begin{aligned} \text{Annualsalesbymodel} &= \beta_0 + \beta_1 Subsidized_i + \beta_2 Subsidizedperiod_{it} + \\ &+ \beta_3 DiD_t + \beta_4 X_{it} + \varepsilon_{it} \end{aligned} \qquad [3]$$

In Table 6 we used the variable *subsidized* as binary. If the corresponding model had 50% or more versions that were subsidized, then the variable takes on a value of 1, otherwise it is zero. In the columns (1), and (2) we used a cluster error term by brand to take into account the heterogeneity of the different brands in our data base. In the case of columns (3) and (4) we used fixed effects by brand. In the columns (2) and (4) we introduce the variable "manufacturer price" that we consider an endogenous variable. In these two cases we use a Two Least Squares and the instruments are: GDP of the country, trunk capacity, a dummy variable that take value 1 if has a power assisted steering, the number of airbags and the horsepower. Results are shown in Table 6.[39]

[39] Like in the price equation we test if the affected and unaffected groups follow the same trend before the Plan. We obtain the same result, we can not reject the null hypothesis that the two groups follow the same trend before the introduction of the Plan. So, the D-in-D estimator shows in an efficient way the effect of the Plan.

Table 6. Estimations of annual sales by model

Explanatory variables	(1)	(2)	(3)	(4)
Subsidized	5,507.2***	3,017.7	3,438.7**	1,400.3
	(1,633.7)	(2,838.2)	(1,637.8)	(3,118.1)
Subsidized period	-1,914.6***	-3,409.5***	-1,733.4***	-2,502**
	(658.3)	(1,246.6)	(624.4)	(1,139.2)
DID Subsidized period	**730.4**	**281.6**	**61.6**	**-1,458.3**
	(1,326.4)	**(2,693.7)**	**(1,243.7)**	**(2,605.1)**
Manufacturer price		-0.06*		-0.03**
		(0.03)		(0.01)
Constant	3,590***	8,396.9***	3,075.6***	4,592.6***
	(919.9)	(2451.1)	(998.8)	(1,534.9)
Observations	602	299	602	299
F-test	5.74***	3.98***	19.65***	17.25***
	(0.0023)	(0.0100)	(0.0000)	(0.0000)
Hansen J Statistic		8.379		9.418
		(0.1365)		(0.1514)
Cluster	YES	YES	NO	NO
Fixed effects	NO	NO	YES	YES
% increase in sales	9.2	3.6	0.8	-18.5

Note 1: *** 1%, ** 5%, *10% significance test. Robust standard errors shown in brackets.

As Table 6 shows, the effect of the Plan on sales defined ranges from 730.4 to -1,458.3 units. We have to take into account that the information is aggregated at annual level, so our empirical estimations have a lot of noise. In any case we calculate the percentage of increase in sales derived of the implementation of Plan2000E. Like we can see in the last row of the table 6, the percentage ranges from 9.2% to the -18.5%. These results are in average close to that obtained in the analysis performed by the Fesvial Company and GfK Emer Ad Hoc Research (2009), in which they reported that the Plan "encourages many individuals to buy a vehicle" based on 5% of the survey participants.

This result is not surprising when we consider the duration of the Plan 2000E, over thirteen months. As indicated Mian and Sufi (2010) and Li et al (2011), the effects of the "Cash for Clunkers" program in United States over the sales are diluted in less than six months, going to have an effect on sales equal to zero. It is possible that the Plan 2000E generated positive effects on sales in the initial months, but unfortunately we have not monthly data on sales to test this hypothesis. In summary, seems clear that the overall effect of the Plan 2000E on sales over its lifetime is effectively zero.

Regardless of the empirical evidence, in the additional columns from the efficiency analysis included in Table 7 we uncovered new demand generating capacities of the Plan, starting with the previously mentioned 100% to 10%.

In terms of the benefits derived from the reduction of polluting emissions, the benefits depend on the capacity of the Plan to create demand for less polluting vehicles. Our survey found that a large percentage of participants would have exchanged their car for a less polluting model even if the Plan did not exist, thus a reduction in pollution levels would have been seen even without the Plan.

As above, the benefits derived from tax revenue depend on the capacity of the Plan to create demand. If, for example, 40% of sales came from newly created demand, then 60% of the users would have changed their car anyway and would still have paid VAT and registration taxes. Personal income tax collection if we must maintain that the collection of cars included in the Plan, independently if the change of car by the introduction of the Plan or not. This is due to the increase in income that is subject to income tax generated as a direct result of the Plan, and without this the increase in personal income tax collection would not have occurred. As we can see, the benefits and therefore the effectiveness of the Plan depend on its capacity to generate new demand.

With respect to the program costs we have only taken into account the expenses assumed by the local and national governments. To calculate these costs we multiplied the total number of cars included in the Plan 2000E (461,838 vehicles) by the 1,000€ subsidy per vehicle contributed by the local and federal government. The costs do not depend in any case on the capacity that this has to create new vehicle demand since the subsidy is given to all of the users that participated in the Plan, not only those who would have changed their car anyway, but also to those who would not have changed their car without the Plan. Results are shown in Table 7.

Table 7. Comparison of revenues and costs for Public Administration derived from Plan2000E, depending on new demand generated

	100	90	80	70	60	50	40	30	20	10
Pollution old vehicles [1]	180	180	180	180	180	180	180	180	180	180
Pollution new vehicles [1]	133.92	133.92	133.92	133.92	133.92	133.92	133.92	133.92	133.92	133.92
Yearly kilometers	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000
Useful life of vehicles (years)	15	15	15	15	15	15	15	15	15	15
Number of car subsidized by the Plan	461,838	461,838	461,838	461,838	461,838	461,838	461,838	461,838	461,838	461,838
Avoided tons of CO_2	7,661,338.214	6,895,204.393	6,129,070.572	5,362,936.75	4,596,802.929	3,830,669.107	3,064,535.286	2,298,401.464	1,532,267.643	766,133.821
Price per ton of CO_2 [2]	14.32	14.32	14.32	14.32	14.32	14.32	14.32	14.32	14.32	14.32
Savings (€) of avoided CO_2	109,710,363.2	98,739,326.91	87,768,290.58	76,797,254.26	65,826,217.94	54,855,181.62	43,884,145.29	32,913,108.97	21,942,072.65	10,971,036.32
Costs of the Plan	461,838,000	461,838,000	461,838,000	461,838,000	461,838,000	461,838,000	461,838,000	461,838,000	461,838,000	461,838,000
Taxes revenues due to Plan	1,220,637,834	1,107,626,075	994,614,316.8	881,602,558.2	768,590,799.6	655,579,041	542,567,282.4	429,555,523.8	316,543,765.2	203,532,006.6
Results	868,510,197.2	744,527,402.3	620,544,607.4	496,561,812.5	372,579,017.5	248,596,222.6	124,613,427.7	630,632.769	-123,352,162.2	-247,334,957.1

Source: Own elaboration.

[1] CO_2 emissions in gr/km.
[2] In euros, according to quotation

Table 8 shows the net effect of Plan 2000E, which strongly depends on the Plan's capacity to create new demand in the market. If we assume that the majority of the 461,838 vehicles would not have been sold without the Plan, the large increase in tax revenue from the Plan would have had a net positive effect, that is, the revenues for Public Administration from the Plan would exceed the costs. However, if new demand creation capacity falls below 30%[40], costs exceed revenues and the plan becomes socially undesirable for Public Administration. This result is very important since it tells us that the Plan is inefficient particularly in that alternative costs with an equivalent cost would further reach better results.

The great majority of costs and revenues considered in table 7 are income transfers from the Government to producers and consumers, which should be taking into account when performing a Cost-Benefits analysis. Nevertheless, the main objective of this section is to determine whether the Plan 2000E is the most efficient policy (the one in which has to invest less funds) the Public Administration has at its disposal to reduce the emissions of CO_2.

According to our estimations, the Plan only generates a new demand of 10% in the best scenario, what means that the consumers who benefit from the subsidy do not change their behavior. As a consequence, reductions of CO_2 are not generated. The amount of CO_2 saved from the new demand creation of 10% is about 766,133.821 tons. When we compare the savings of avoided CO_2 with the costs of the Plan 2000E that the Public Administration must bear, which are approximately 461 millions euros, we obtain that the proportion of cost per ton is close to 602€, when the value in the market of these tons is 14.32€. Knittel (2009) estimated a cost per ton of 365-237$ in the "Cash for Clunkers" program of United States, and Li et al (2011) between 288 and 91 dollars for the same program.

Available information concerning the impact of public assistance on the generation of new demand in the automobile industry seems to show that the results of Plan 2000E are far from the percentage levels that make a Plan beneficial from the perspective of Public Administration. Furthermore, our data clearly indicate that the implementation of the program resulted in a net loss for the Spanish economy. As we observed in the Introduction of this study, research has shown that the capacity to create new demand based on public assistance is about 20%.

At the time of writing this, there was no academic reference on Plan 2000E in the literature; this was the only study to analyze the impact of automobile demand on environmental efficiency. Nevertheless, as stated earlier, Fesvial Company and GfK Emer Ad Hoc Research (2009) carried out a survey of 1,061 individuals in which they assessed whether Plan 2000E encouraged them to change their car. When faced with the specific question "How much has the new Plan influenced you to purchase a car in 2009?" only 5%

[40] The analysis carried out revealed that a Plan 2000E value of 29% new demand creation would be beneficial for Public Administration, while we do not consider income transfers to producers and consumers.

answered "a lot" and about 15% replied with "somewhat", while the remaining 80% did not show any intentions of changing their car because of the Plan. Thus, it seems that Plan 2000E at best led to new demand creation of 20%, a figure quite similar to the one obtained for the case of hybrid cars in the North American market. The econometric estimate indicates that the effect on sales by the Plan is about 5%.

Table 8 shows the results for different studies in addition to the results obtained from the present survey on Plan 2000E.

Table 8. New demand generated by public subsidies

Article	Country	Year	Type of vehicle	Subsidy quantity	Net effect on sales
Gallagher and Muehlegger (2011)	USA	1999-2006	Hybrid	2,000-3,400$	22%
Beresteanu and Li (2011)	USA	1999-2006	Hybrid	2,000-3,400$	20%
Li et al (2011)	USA	2009	Conventional	3,500-4,500$	0%
Chandra et al. (2010)	Canada	2000-2007	Hybrid	1,000-3,000$	26%
Huang (2010)	USA	2009	Conventional	3,500-4,500$	25-30%
Mian and Sufi (2010)	USA	2009	Conventional	3,500-4,500$	0%
Diamond (2009)	USA	2001-2006	Hybrid	2,000-3,400$	18%
Fesvial and GfK Emer Ad Hoc Research (2009)	Spain	2009-2010	Conventional	2,000€	5%
Our study	Spain	2009-2010	Conventional	2,000€	0%

Source: Own elaboration.

Therefore, the capacity to create new demand by public assistance programs requires in all cases a figure of about 20%, which is greater than the result of Plan 2000E this leads us to the conclusion that Plan 2000E was not socially desirable. With this level of new demand creation, the Plan would have generated social welfare losses of €123 million. Note that at this percentage, the benefits of the Plan do not even cover the public sector expense (€1,000 per vehicle). If the impact of the Plan on the generation of new demand is 5% as indicated by our forecasts and the survey carried out by Fesvial and GfK Emer Ad Hoc Research (2009), the losses would add up to more than €309 million.

These results are reported despite the very favorable Plan assumptions: 15 year vehicle lifetime, 24,000 kilometers per year use, and approximately 130 grams of CO_2/Km recommended by the E.U.; all of which contribute to the avoidance of greenhouse gas emissions. In addition, we assumed that the consumers who decided to change to a subsidized vehicle did so because of the Plan (the alternative being not to change at all) when actually it is possible that many consumers changed to cars that are non-subsidized yet less polluting. Thus, we have also obtained a reduction in pollution. It is clear that if we changed some of these assumptions the results from the Plan would only worsen social

welfare. These assumptions clearly indicate that from an environmental perspective, Plan 2000E was an inefficient policy introduction.

As an alternative to direct assistance programs, there is a growing popularity in the economic literature towards increases in fuel tax and energy efficient vehicle standards. Greene et al. (2005) showed how a tax system in which taxes are fixed on vehicles with energy efficiency below a certain level, and whose revenue serves to subsidize the most efficient vehicles, would significantly increase the energy economy of the vehicles.

Austin and Dinan (2005) compared how the modification of vehicle standards and/or the increase in fuel tax help reduce pollutants. The results of the simulation model highlight that the tax increase caused greater immediate savings than the modification of standards because it introduced individual incentives to drive less and choose more energy efficient vehicles.

Linn and Klier (2007) also reported that when faced with an expected increase in fuel prices, driving costs increased for the less efficient cars, creating new demand for more energy efficient vehicles. The authors estimated than an increase in fuel price of one dollar caused an increase in the energy efficiency of new vehicles by 0.5 miles per gallon of fuel.

The capacity to reduce vehicle pollutants by taxes has also been observed by Sterner (2007). In this study the author shows that fuel consumption, and therefore pollution levels, would be much higher if fuel taxes did not exist within the countries in the OECD. This evidence leads the author to conclude that fuel taxes are the most powerful instrument in the fight against climatic change.

Similarly, Ryan et al. (2009) observed that the Road Fund Tax is the most efficient mechanism to reduce pollution levels of the vehicles within the countries of the European Union. Specifically, an increase of 10% in the Road Fund Tax caused a reduction in pollution levels of the fleet of vehicles equal to 0.3 grams per kilometer in the short term, which increased to 1.4 grams per kilometer in the long term.

To summarize, it seems that tax mechanisms (i.e. fuel taxes and vehicle taxes) have a greater influence on the pollution levels of the vehicles and imply a lower cost for local, regional and national governments[41].

5. Conclusions

The automobile industry is one of the most important manufacturing sectors for current national economies. Their high production values and their labor intensity continue to have an important effect on governments, namely that they are traditionally concerned about the development and stability of this industry in its territories.

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[41] Bento et al (2009) also show that the distribution of the resources obtained from the tax increase can improve income distribution. If the resources were uniformly distributed, the average households in the last four income percentiles would improve their situation. If the resources were shared proportionally to income level, only the highest and lowest percentile would improve their social welfare.

With the economic crisis affecting many developed countries since 2008, the automobile industry has reported a significant drop in sales, resulting in increased unemployment in the sector. Faced with this situation many governments have introduced programs to stimulate the replacement of old cars for new vehicles through scrappage schemes, with two main objectives: to increase automobile sales and reduce pollution levels.

Even though these programs are important there is an absence of empirical evidence on their effects. Studies on scrappage schemes in the United States have shown how this type of program can lead to an increase in sales of approximately 20%, however, we know nothing about the European market.

At the same time we do not know what effect the programs can have on the prices set by the manufacturers and whether these programs are desirable effects i.e. whether the costs of the program are lesser or greater than the benefits generated.

This study analyzed the effect of the prices fixed by manufacturers in Plan 2000E, which is a Spanish program that offered a subsidy of 2,000€ to consumers to replace old vehicles with newer, less polluting ones. It was co-financed by the manufacturers (€1,000 euros), National Government (€500 euros) and Autonomous Communities (€500 euros).

Using difference-in-difference we observed that the Plan caused an increase of 1,000€ in the price of subsidized cars, meaning that the subsidy of 2,000€ ended up being shared between the consumers, who would only receive a net discount of 1,000€, and the manufacturers, who would receive the remaining 1,000€. The matching estimator, applied to solve some of the problems of the diff-in-diff estimations, shows similar results.

Thus, the success of the Plan in achieving its objectives was limited since half of the fixed subsidy in the program went to the manufacturers and did not generate any type of incentive to the consumer to exchange vehicles for less polluting ones.

In addition to the first estimate of the net effects generated by Plan 2000E it is also clear that the Plan did not generate results for Public Administration. Even though we assumed favorable hypotheses, the result of our forecast was a negligible capacity to generate new demand of only 5%, compared to the 30% required to make the program efficient.

From the empirical analyses carried out in the United States and the survey of Plan 2000E, the estimated increase in demand capacity was approximately 20%. Assuming this 20% capacity for the generation of new demand, the program leads to losses of more than 123€ million, which would increase if the capacity to create new demand was lower. Losses would be greater than 300€ million with a 5% change in demand.

The results are clearly conclusive: the program is inefficient, subsidizing a large part to the manufacturers directly instead of the consumers. In addition, the high costs of the program and its reduced impact make Plan 2000E undesirable from Public Administration perspective.

If the real objective of government is to reduce the level of pollution caused by the vehicle fleet, economic literature has shown how other more efficient mechanisms exist and are

less costly to the sector. The increase of fuel taxes or the fixing of more severe energy efficiency standards are examples of alternative mechanisms that can help meet goals in pollution prevention.

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